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ABSTRACT

In November 1997, the National Institute for Science Education (NISE) brought together for a two-day conference faculty members of NISE, individuals who have special expertise or experience pertaining to interdisciplinary collaboration and problem solving and representatives of research projects addressing the topic of interdisciplinarity. The purpose of the conference was to advance understanding of interdisciplinary teamwork and to identify areas for further research. This report provides a synopsis of the issues and ideas that emerged during the conference, including key questions for research, the role of theory in research--particularly theoretical frameworks within the field of cognitive science, methods and methodology, and other general issues. In addition, the report reviews implications for practice of what is known about interdisciplinary collaboration and important considerations for designing effective environments for such collaboration. (Author)

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National Institute for Science Education

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Workshop Report No. 5

Understanding Interdisciplinary Teamwork: Challenges for Research and Practice

The report of a conference organized by the Cognitive Studies of Interdisciplinary Collaboration Project Madison, Wisconsin 15-16 November 1997

Laura Lee Gance

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About the Author

Laura Lee Gance is a senior research specialist with the Cognitive Studies of Interdisciplinary Collaboration team of the National Institute for Science Education. She comes with 20 years experience working with interdisciplinary research groups in the earth sciences. She joined the staff of NISE the day of this conference as a way of broadening her understanding of group dynamics in interdisciplinary collaborative endeavors. Her focus is on the function of conflict in group process and outcomes through the use of discourse analysis methods.

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Preface

In November 1997, the National Institute for Science Education (NISE) brought together for a two-day conference faculty members of NISE, individuals who have special expertise or experience pertaining to interdisciplinary collaboration and problem solving, and representatives of research projects addressing the topic of interdisciplinarity. The purpose of the conference was to advance understanding of interdisciplinary teamwork and to identify areas for further research. This report provides a synopsis of the issues and ideas that emerged during the conference, including key questions for research, the role of theory in research -- particularly theoretical frameworks within the field of cognitive science, methods and methodology, and other general issues. In addition, the report reviews implications for practice of what is known about interdisciplinary collaboration and important considerations for designing effective environments for such collaboration.

Introduction

The National Institute for Science Education (NISE), funded by the National Science Foundation (NSF), comprises a number of interdisciplinary teams working on a variety of issues related to science, mathematics, engineering, and technology (SMET) education. Many of the current goals and strategies of NSF's Directorate for Education and Human Resources involve promoting interdisciplinary inquiry into the problems of education. Interdisciplinary teams are increasingly common in industry, government, and society in general and are often utilized to guide and facilitate decision-making processes. A substantial body of literature and much "wisdom of practice" on interdisciplinarity have emerged in recent years; nevertheless we still have limited scientific understanding of how social and cognitive processes interact to drive intellectual growth and construction of intellectual products in interdisciplinary groups doing research on important societal problems. Such understanding would inform the design of better procedures and technologies for improving interdisciplinary collaboration and effort.

The goals of the Cognitive Studies of Interdisciplinary Collaboration (CSIC) team of NISE are to understand interdisciplinary collaboration and improve such collaboration within the Institute. Key outcomes of this research are expected to be contributions to sociocognitive theory as well as the ability to facilitate more productive communication and better designs for team-based work.

To further understanding and help refine the research objectives of CSIC, the team brought together for a two-day conference faculty members of NISE, individuals with special expertise or experience pertaining to interdisciplinary collaboration and problem solving, and representatives of research projects addressing the topic of interdisciplinarity. There were 31 participants in attendance at the Conference on Understanding Interdisciplinary Teamwork, held at the University of Wisconsin–Madison, 15-16 November 1997. The program and the participant list are appendixes in this report.

The conference began with a keynote address by Professor Julie Thompson-Klein, Wayne State University, that reviewed the history and characteristics of interdisciplinarity and teamwork.[1] Later, in a special lecture, Professor Gavriel Salomon, University of Haifa, presented his ideas on the concept of distributed cognition. Other participants presented research on teams and interdisciplinary collaboration, technologies developed to support collaborative work and learning, and their experiences as participants in interdisciplinary teams. On the second day of the conference, participants broke into five working groups to explore in depth the roadblocks to interdisciplinary collaboration, the most pressing and important research questions to be addressed, the role of theory in the study and practice of interdisciplinary collaboration, as well as the potential and criteria for creating effective environments for collaborative work through the use of technology. As a community of researchers studying interdisciplinary collaboration, participants also considered mechanisms for strengthening communication and integration of research findings among themselves.

This report provides a synopsis of the issues and ideas that emerged in discussions during the conference.

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[1] The text of Professor Klein's keynote address is being published as an NISE Monograph.

Interdisciplinary Collaboration: What Is It?

Definitions of interdisciplinary problem-focused research vary depending on the degree of collaboration occurring. On one end of the spectrum is a simple communication of ideas, where individual expertise is utilized and evaluated on a solitary basis. In this type of collaboration, individuals maintain their own disciplinary viewpoints, and tasks might be divided according to individual disciplinary backgrounds. At the other end of the spectrum, where responsibilities are shared equally by all in a full partnership, is the possibility for the transformation of disciplinary boundaries – a restructuring of knowledge, not just an avenue to build better bridges for problem solving. Between these two points on the spectrum, interdisciplinary collaboration denotes integration of ideas and understanding around a core problem, topic, issue, or question. At times different terms have been used to refer to these various states of collaboration, with multidisciplinary teams representing teams on the simple communication end of the spectrum and true interdisciplinary teams falling more on the full partnership end. For the purposes of this report, however, the term *interdisciplinary* is used to denote any team comprising multiple disciplines.

Groups and teams have a dynamic nature with group, interpersonal, and intrapersonal currents interacting at all times. Key aspects of groups and teams are:

- *The task* – either directed goals aimed at achieving specific and well-defined ends, or dynamic goals aimed at achieving broader states or conditions that must be pursued continually or maintained once they have been achieved
- *The team* – its size; timeframe of existence; physical location and proximity; gender, racial, and cultural composition; the disciplines, professions, and functions represented; and experience of members
- *The organizational context* – its structural make-up, culture, and resources of time and budget
- *The integrative process* – degree and modes of collaboration, leadership style, and communication style

The distinguishing feature of interdisciplinary teams is the presence of individuals from different fields of expertise. These fields are not only disciplinary or professional in nature, but may also serve different functional roles (e.g., administrative, research, marketing) in different types of organizations such as industry or government. Even though interdisciplinary teams are heterogeneous, members tend to be interdependent on each other.

What Are the Obstacles?

Many of the potential obstacles to interdisciplinary collaboration and teamwork are common to all groups, while others are unique to interdisciplinary endeavors. Aside from the obvious, that personalities always matter, collaborative groups confront problems that include:

- *Shared understanding of the task.* Even clearly defined goals or consequential, tangible products may not be understood in mutually compatible ways by the members of a team.

Developing objectives and goals collaboratively increases the possibility for shared understanding and ownership, but adds another dimension of complexity.

- *Team dynamics*. Individual members' lack of experience working in collaborative groups can slow progress. Shifting membership within the group results in a lack of ability to generate and maintain a shared and stable culture, group memory, sense of humor, etc. Different levels of motivation and accountability among members can lead to insecurity and mistrust.
- *Power imbalances*. Professional pecking orders, gender, culture, race, and who has the last word, all enter into the team's process and dynamic. Those with perceived higher status are more likely to be heard than those who are perceived to be of lower status. Those whose input comes in design development rely on the goodwill of those who later implement the design.
- *Stereotypes about others' roles*. Even people who presumably work in the same business often hold inaccurate stereotypes about how other disciplinary representatives actually work. These stereotypes can lead to unrealistic expectations of the roles others will fill and the nature of their contributions.
- *Technical challenges*. Finding ways to capture and document the ideas, depth, and progress of group work is critical, though often overlooked.
- *Institutional constraints*. The organizational context in which a team operates has significant impact on the work of a team or group. Politics, funding, and time constraints can undermine group efforts. Lack of clearly articulated leadership can result in groups floundering.

Interdisciplinary efforts in academic settings have another layer of complexity:

- *Disciplinary expertise and culture*. An inability to move out of individual disciplinary perspective or "unpack" one's own disciplinary epistemology creates obstacles for developing understanding among members.
- *Disciplinary and methodological pecking order*. Interdisciplinary teams are status systems that reflect not only external hierarchies (gender, race, cultural background, professional status) but also a disciplinary chauvinism (particularly with regard to quantitative/qualitative methods, including distinctions and perceptions of various disciplines of science as "hard" and "soft," "subjective" versus "objective"). Different argumentation styles and status often affect what information is attended to in group efforts.
- *Territory battles*. Often the most serious miscommunications occur among people who are "near neighbors" professionally. Even though there may be a lot of common terminology, it may carry very different meanings. Moreover, different beliefs and conceptual understandings, as well as professional objectives, can be difficult to work through.
- *Tool incompatibility*. There are often problematic mismatches between the tools and goals of one discipline and those of another.
- *Inadequate reward system and performance measures*. Collaborative work done outside of one's primary discipline doesn't tend to advance an individual within his or her discipline. Collaboration also introduces issues of ownership and publication: in a group, whose idea is it?

Disciplines, by their very nature, have an established language and methodology, have identified key problems worth studying, and have determined necessary characteristics of evidence as well as methodology. Individuals develop expertise within their chosen discipline by acquiring basic cognitive knowledge and skills – a process that moves from conscious, to associative, and finally to the autonomous cognition that characterizes expertise. The benefits of autonomous skill are a reduction in working memory demands, a reduction in verbal scaffolding, and an increase in speed. But what makes an expert within a field may not make a good educator or collaborator. Indeed, the more "automatic" cognition processes are, the more difficult it becomes for an individual to break down and elucidate each of the steps taken to carry out his/her disciplinary process of research. This process implies significant difficulties in the transition from individual cognition to joint cognition within interdisciplinary groups that comprise experts. Some of the cognitive difficulties for interdisciplinary team work include:

- unpacking expertise in group communication by returning proceduralized knowledge to a less automated form
- developing a common language to reduce processing demands
- identifying and obtaining necessary shared knowledge for the task
- creating new knowledge structures for new information
- representing the task
- managing working memory demands in groups
- negotiating coordination and executive control

Being "conscious" may increase frustration and impatience for participants. However, such cognitive conflict is intrinsic to the presence of different disciplines, and its occurrence allows participants to identify problem areas and misunderstandings – a prerequisite for developing shared knowledge and understanding.

Conflict in general is associated with both technical issues (definition of problem, research methodologies, scheduling) and interpersonal issues (leadership style, disciplinary ethnocentrism, different argumentation styles). In interdisciplinary teams, the complexity of problem-focused tasks and interdependence of working relationships create greater opportunities for ambiguity and conflict. Conflict, moreover, does not go away. It occurs throughout the lifetime of a project, task, or course as team members work through differences and attempt to resolve them. In this sense, conflict is inescapable and necessary to the functioning of interdisciplinary team work.

Considerations for Research on Interdisciplinary Collaboration

During plenary and working group sessions of the conference, discussion focused on a wide range of topics concerning research on interdisciplinary collaboration. These topics included the key questions, the role of theory, methodology, and other general issues.

Key Questions

Conference participants considered the critical unknowns about interdisciplinary collaboration. Three key areas of focus were identified: the interaction between individual and group processes and dynamics, the intersection between stability and change in group functioning, and the environmental factors that impact the way interdisciplinary groups operate. Research should explore not just the dimensions of interdisciplinarity, but the causal elements of which the interaction is the core. This includes how a group works in relation to its product, that is, both process and product. Within these general areas, the most pressing and important questions for research on interdisciplinary collaboration were determined to be:

- *Nature of interdisciplinarity.* What are the dimensions of interdisciplinarity? What is the definition of interdisciplinarity and how is that different from disciplinarity? What are the properties? On what dimensions do we differentiate disciplines? Do disciplines actually exist or are they merely perceived to exist?
- *Dynamics of interdisciplinary groups.* What are the factors and processes of formation and maintenance of interdisciplinary groups? Are they similar to or different from disciplinary (noninterdisciplinary) groups? How is stability maintained within a group? What are the interrelationships among social/personality and cognitive factors? What is the relationship between individual and group actions, recognizing that the work of interdisciplinary teams involves both group and individual efforts?
- *Measurement issues.* What are the dimensions of success (effectiveness) of interdisciplinary groups and teams that can be evaluated? What are the characteristics (predictors) of successful interdisciplinary groups and teams? Are these characteristics or properties stable enough to be used as predictors? On what different base(s) can success be determined? Does it vary across contexts?
- *Tools and technology.* What are the potential and actual roles of technology in interdisciplinary teams and groups? How does technology mediate performance? What is its constitutive impact? What, if any, is the biasing influence of technology on how groups think and work?

The Role of Theory

Conference participants discussed the role of theory in the study of interdisciplinary collaboration and identified the most promising theoretical ideas and perspectives for approaching this work. As conference participants began this discussion, the question of whether to propose a new discipline of interdisciplinarity was raised. While certain potential benefits were identified, such as more research activity and sponsorship, it was acknowledged that disciplines are not generally "created," instead they emerge. This issue, though, illustrates one of the central questions participants grappled with: One theory or many theories?

There are many theoretical frameworks that provide particular perspectives and associated methodologies for analyses of interdisciplinary collaboration. Each theoretical framework has its own strengths and weaknesses, and each addresses different dimensions of group collaboration. Thus, the first step is to determine which framework is good for what types of questions, what is the unit of analysis, and which frameworks are incompatible. Each theoretical framework needs to be evaluated for what it offers, its advantages and disadvantages, especially with respect to levels and units of analysis. The issue of theoretical

incompatibility was discussed, specifically: Are theories of social practice and cognitive science compatible or mutually exclusive?

Even though integrating different theoretical notions concerning interdisciplinarity would be extremely difficult, it was agreed that the study of interdisciplinary collaboration cannot be handled by any one discipline. Indeed, knowledge about interdisciplinarity exists within many fields, including management and organizational theory, social psychology, anthropology, and education. Participants agreed that an analytical synthesis is needed to bring together and organize the information from the individual disciplines to enrich the understanding of interdisciplinarity across all disciplines.

Participants also agreed that macro-studies of interdisciplinarity would provide perspective on its cycles and patterns. Interdisciplinarity may take place in generational cycles. People come together to reorganize the study of thinking and learning, and these primary participants go back to the fields they came from, thereby enriching their individual disciplines.

Theoretical Frameworks Within the Field of Cognitive Science

In her presentation, Angela O'Donnell reviewed several possible frameworks within the field of cognitive science, broadly defined, for studying cognition and tool use as they occur within groups:

- Information processing is a traditional model of individual cognition applied to multiple participants.
- Sociocultural theory looks at the role of community in the development of shared knowledge structures.
- Situated cognition attempts to characterize context, examines representations, and addresses the problem of whether we are proactive or reactive organisms.
- Distributed cognition may incorporate any or all of the approaches above, but also looks at what is being distributed, for what purpose, what the source is, what the mechanism is, and what the effects are.

Participants noted that the information processing analog for describing group process does not extend to define group counterparts for human memory structures and processes. An adequate information processing model for groups would appear to require the reconceptualization of concepts such as long-term and working memories, attentional processes, and executive control to better describe the collective case.

This reconceptualization is taking place to some extent within the literature on "distributed cognition." The typical unit for analysis in this literature is the "activity," such as a single discussion within a meeting. Hence, a system of distributed cognition is to some extent a transient artifact of a particular situation – for example, the collection of capabilities and ideas mobilized for a particular team meeting.

Using a hypothetical group activity as an example, Gavriel Salomon, in his special lecture during the conference, depicted a group's long-term memory as the salient, activity-relevant information network that is distributed across group members' individual long-term memories. Within this network, some ideas (represented as nodes) were viewed as unique to single individuals; other nodes represented shared information held in common by two or more members. Shared information thus provides potential bridging relationships among otherwise privately held knowledge stores, linking all data in collective long-term memory.

Methods

Conference participants talked at some length about methods and methodology as they pertain to the study of interdisciplinarity. The discussion began on the distinction between reality and discourse, on what can be directly observed and what must be inferred. Depending on where one believes meaning is located, whether in the discourse, actions, and/or artifacts of a group, then one must use methods appropriate to discovering meaning in that location.

There was extended discussion using the metaphor of *methods as tools*. Tools were considered prisms with which to look at the world. An example was given of L. Guttman's Small Space Analysis that was characterized as a way to map a number of variables in order to show their relationships to each other. It is a way of viewing the system as a system, not as a collection of variables examined one by one. Rather than looking at the patterns of differences (as in traditional experimental research), one looks at the differences of patterns to see how the configuration of variables – what becomes central and what becomes peripheral – has changed over time and what dimensions organize the different variables.

Collectively, methods were likened to a tool kit: the larger the variety, the better choices one has. But it may be appropriate to study the tool kit to understand the strengths, weaknesses, and applicability of individual tools.

Participants considered the importance of naturalistic observations and how the setting under study shapes the phenomenon of interest. For example, research in a psychological laboratory aims to verify a rational analysis whose structure, it is hoped, represents the task at hand. Yet in studies at schools, children are often seen disassembling the task and reassembling it in ways that redefine the task. In this case, what is considered error in the laboratory becomes the phenomenon of study.

Participants noted that methods are associated with disciplines and subdisciplines, such that the entire tool kit is not available to every discipline. Some methods delete phenomena in irretrievable ways, thus it is a tool kit that requires strategic choices. Selecting certain tools also brings along theoretical baggage. Indeed, rules of validity are not just theory dependent but also paradigm dependent. Yet, often, different disciplines do not differ in the methods but rather in the rules of admission of evidence. In psychology, for instance, researchers have moved beyond experiments to employ

qualitative methods such as observation and interviewing that earlier were welded to other particular theories or disciplines.

Nevertheless, some methods do not work for particular questions. For example, interaction analysis is not a viable method for hypothesis testing because it is oriented toward hypothesis development. This point opened another strand of the discussion about whether hypothesis testing required quantitative methods. There was general consensus that quantitative methods were most suited for hypothesis testing. Other methods were said to be applicable, but no examples were given.

General Issues

Several other important issues arose in the course of the conference. Participants raised the question of what situations and for what types of tasks teams are more appropriate than individuals. A related question arose concerning interdisciplinarity and whether it is primarily an issue in academia or has broader relevance. Participant discussion of the goals of research led to a discussion of who the audience of research is. Last but not least, participants considered the ways in which ethical concerns affect the types of studies that can be undertaken and how they are reported.

When is N + 1 better than 1? That is, when is the use of teams appropriate and when is it not? This question prompted a long discussion. Two fields, cooperative learning and research on medical teams, were identified as providing some examples of research on that question, along with the wisdom-of-practice statement, "When the task is too large or too complex for one." For even though a complex task may clearly require a range of expertise that only a team effort can provide, there are no guarantees that the task will be carried out successfully given the multifaceted nature of team work. The number of variables that affect performance is so large that no single study can deal with all of them. Moreover, participants wondered how "successful" outcomes would be defined, by what criteria success would be determined. Concern was expressed that focusing primarily on the task outcomes may give an overly simple view of the utility of the experience of working on interdisciplinary groups and teams. Such a view doesn't take into consideration that things like organizing and managing long-term memory and building distributed skills will allow individuals and teams to work more effectively later. Even the silent participation of people in group activity is often an occasion for them to gain access, to hear, to see, to learn about what is going on, which may be consequential to their future contributions within this larger collective.

Interdisciplinarity. The issue of studying interdisciplinarity as a phenomenon itself was raised several times during the conference. Monodisciplinary activity may be a fiction of academia, since outside academia interdisciplinary work is often the norm. In business teams, if particular expertise is needed, it is added to the group, thereby maintaining almost constant interdisciplinary team composition. One participant noted that the emphasis on disciplines in academia and on interdisciplinarity in business may have arisen because business groups are formed to solve problems (which often require multiple sets of skills), whereas academic groups are focused on communicating the basis of a discipline to others.

Along with the specific points that were made during the discussions on both teams and interdisciplinarity, two divergent yet related views emerged. First, it is important not to presume that teams are appropriate for every sort of task or situation. Clarifying through research what tasks and situations are appropriate would be helpful. Second, interdisciplinary collaboration is, nevertheless, an integral part of how work is accomplished, across all spectrums. Thus, treating it as a natural phenomenon to be explored is appropriate and necessary.

The goal of research. Discussed at some length was the question of whether the goal of all research, including research on interdisciplinary teams, is hypothesis testing. Should researchers give up hypothesis testing? Is there any role for hypothesis testing? Is it feasible to test hypotheses in research on interdisciplinary teamwork? One participant suggested that socioculturalists have given up testing and instead are generating hypotheses. Another participant pointed out that not all research programs need to test hypotheses as long as there are some research programs doing hypothesis testing. There are two aspects to this process – hypothesis generation and hypothesis testing – and both are required. Participants concluded that even though qualitative methods are appropriate for generation and refinement of theories and hypotheses, quantitative methods and statistical analysis are most suitable for hypothesis testing.

It was widely agreed that one goal of research is to generalize from particular cases. One participant suggested that a comparative analysis of two cases permits the development of grounded theories that allow one to generalize in certain situations.

Who is the audience? One participant proposed that an important outcome of research and theorizing is to change practice. Others wondered what would convince an audience (in this case, practitioners) to improve their practice. *Who* the audience is for research on interdisciplinarity was discussed at some length. Does it comprise practitioners, other researchers, and/or the wider public? Who the audience is determines how one formulates a report of research findings. For example, statistics are part of a very specialized discourse that is important and comprehensible to researchers, but that the wider public, even practitioners, would not be expected to understand. Yet this doesn't mean that researchers should stop using statistics. The question of what methods to use should not be limited by what can be explained to the public.

Discussion on the general public's access to research findings brought up an example of the use in business of "management by best seller." Businesses jump from one management fad to another, following on the current best selling management guide. In education teachers often resist initial formulations from theorists because they want to see whether it is just a fad or is something that will endure. Most agreed that science is most concerned with assembling knowledge brick-by-brick, so the methods employed are most useful for understanding a single brick. It is often left to the practitioners to somehow integrate the bricks into their practice. Unfortunately the process is not one where simply taking a small-scale phenomenon and expanding it into a large-scale situation is

necessarily appropriate. Nor is a laboratory phenomenon equivalent to a real life phenomenon.

Ethics. The discussion also included a consideration of ethics and the role of the researcher. It is problematic to faithfully represent a particular situation under study if various participants would be shown in a bad light. These concerns often limit the kinds of questions that can be asked. On the other hand, leaving out controversial parts of a report misrepresents the situation. Often, people refuse to participate at the outset, which limits the range of settings that can be studied.

Implications for the Practice of Interdisciplinary Collaboration

From an applied practical perspective, it was suggested that clarifying individual and disciplinary "identity" can improve collaboration by making explicit the implicit nature of expertise. When people representing different disciplines work together, they must first represent for themselves their discipline's assumptions, values, and goals; only then can they begin to communicate those ideas to others. As has been noted earlier, this is no easy task. To accomplish this difficult task, members of interdisciplinary teams need to:

- Develop reflective awareness
- Make clear to themselves and others their ways of knowing, their epistemologies and paradigms
- Recognize what they take for granted that is not taken for granted by other team members
- Acknowledge background and status differences

In one sense, cognitive conflict among team members may be productive by sparking recognition of assumptions that constitute disciplinary identities.

The most successful interdisciplinary collaborators are often those who are willing to take on, at least provisionally, the perspectives, values, and goals of their collaborators. These "bridge people" can play an important role in overcoming disciplinary differences. Success of a team frequently depends on participants who are able to go beyond pronouncing weaknesses or problems with a product and to begin working on solutions.

Experience on interdisciplinary teams suggests that products encourage progress. In a design problem, group memory resides in the current version of the thing being designed. The design reifies or embodies within it a history of the decisions made up to that point. Moreover, a tangible product of some kind, especially if it needs to work or perform in agreed-upon ways, serves to provide feedback to disparate group members that can be used to forge consensus about next steps. It also serves to organize conversation and highlight occurrences of miscommunication.

There are also tools and skills that can provide crucial support to the collaborative effort. New technological tools such as computer systems and electronic communication systems have been designed to support collaboration and teamwork. This field is rapidly growing and promising for research. The potential of these tools is not yet understood.

Finally, participants noted the dangers of ritualization. If successful collaborations are forged, there is a tendency to ritualize them by reifying the processes whereby they emerged. Unfortunately, interdisciplinary collaboration cannot be prescribed and guaranteed. It has to be re-invented anew each time.

Considerations for Designing Effective Environments for Interdisciplinary Collaboration

In considering how technology and management strategies can be used to create more effective environments for collaborative work, one primary question emerged: Should technology drive and shape the work environment, or should technology be driven by the activity or by the users? Many groups will not identify and utilize technologies on their own, so it falls on those who are more aware of technological capabilities and options to educate potential users. However, this must be done with sensitivity, perhaps through an iterative piloting of new technologies, thereby building on small successes. One first step is expanding the notion of technology to include more than just computers. Other considerations for creating effective environments for collaboration include:

- Provide ongoing support for users of new technology
- Give supportive management and organizational commitment and sense of responsibility
- Attend to the cultural context of the collaboration
- Consider users'/participants' needs
- Focus on creating technology that is neither monolithic – flexible components, modular, platform independent – nor invasive

Conclusions

The objectives of the conference were to advance understanding of research on interdisciplinary collaboration and to help refine the research objectives of CSIC. Participants went further, though, by formulating a broad research agenda for the community of scientists studying interdisciplinarity. Four primary research areas were identified:

- *Nature of interdisciplinarity*. What are the dimensions of interdisciplinarity? What is the definition of interdisciplinarity and how is that different from disciplinarity? What are the properties? On what dimensions do we differentiate disciplines? Do disciplines actually exist or are they merely perceived to exist?
- *Dynamics of interdisciplinary groups*. What are the factors and processes of formation and maintenance of interdisciplinary groups? Are they similar to or different from those of disciplinary groups? How is stability maintained within a group? What are the interrelationships among social/personality and cognitive factors? What is the relationship between individual and group actions, recognizing that the work of interdisciplinary teams involves both group and individual efforts?
- *Measurement issues*. What are the dimensions of success (effectiveness) of interdisciplinary groups and teams that can be evaluated? What are the characteristics (predictors) of successful interdisciplinary groups and teams? Are these characteristics or

properties stable enough to be used as predictors? On what different base(s) can success be determined? Does it vary across contexts?

- *Tools and technology*. What are the potential and actual roles of technology in interdisciplinary teams and groups? How does technology mediate performance? What is its constitutive impact? What, if any, is the biasing influence of technology on how groups think and work?

In addition, conference participants recommended that certain steps be taken to facilitate and situate the basic research agenda outlined above. These included:

- An evaluation of each theoretical framework for its advantages and disadvantages, the types of questions each lends itself to, particularly with respect to levels and units of analysis and for theoretical compatibility.
- A synthesis of information from the many individual disciplines that have studied aspects of interdisciplinarity.
- Studies of the phenomenon of interdisciplinarity itself to determine what cycles and patterns of its occurrence can be discerned and what its impact is beyond academia.
- A study of the methods, the "tool kit," to understand the strengths, weaknesses, and applicability of individual tools.
- An assessment of what tasks and situations are appropriate to teamwork and which are not.

Conference participants also called for more activity and sponsorship of research on interdisciplinary collaboration to address the many scientific unknowns noted above. Moreover, participants felt that similar conferences should occur regularly. This would provide the multidisciplinary community of researchers studying interdisciplinary collaboration an opportunity to share recent findings and new research ideas, learn about new approaches to studying collaboration, and continue building their community.

Appendix A: Conference Program

"Understanding Interdisciplinary Teamwork:
Challenges for Research and Practice"
Room 259 - Educational Sciences Building
UW- Madison
November 15-16, 1996

FINAL AGENDA

Friday, November 15, 1996

8:00-8:30 *Continental Breakfast - Educational Sciences Building, Room 259*

8:30-9:15 Welcome, Introductions, Opening Remarks
- Sharon Derry - Director, NISE Cognitive Studies Project
- Andy Porter - Director, Wisconsin Center for Education Research, Co-Director NISE

9:15-10:00 "The Interdisciplinary Factor in Teamwork and Collaboration"
- Julie Thompson-Klein - Wayne State University

10:00-10:20 "Cognitive Processes in Interdisciplinary Teams"
- Angela O'Donnell - Rutgers University

10:20-10:30 *BREAK*

10:30-11:15 "Virtual Collocation and Collaborators: Analyzing and Supporting Group Work"
- Stephanie Teasley - University of Michigan

Discussion of O'Donnell and Teasley presentations

11:15-12:15 "Learning to Make Collaborative Learning Technology Work: A Case Study of CaMILE"
- Cindy Hmelo - University of Pittsburgh

"Computer Support for Group Memory and Group Learning"
- Gerry Stahl - University of Colorado

Discussion of Hmelo and Stahl presentations

12:15-1:30 *LUNCH on 13th Floor, Ed Sciences Building*

1:30-2:30 *PUBLIC LECTURE:*

"Interdisciplinary Distribution of Cognitions:

Much Ado About Something"

- Gavriel Salomon - University of Haifa, Israel

Presentation in Room 228, Ed Sciences Building II

2:30-2:40 *BREAK/Return to Room 259*

2:40-3:40 "Using Collections of Web Technologies to Support Group Learning"

- John Smith - University of North Carolina

"TAPPED IN: An On-line Workplace for Teacher Professional Development"

- Mark Schlager - Center for Technology in Learning

Discussion of Smith and Schlager presentations

3:40-3:50 *BREAK*

3:50-4:20 "GroupWare in Education"

- Jim Metzdorf

4:20-5:30 Discussion and wrap up

Hands on demonstration for those interested

6:00 *Cash Bar Reception at the Concourse Hotel*

7:00 *DINNER RECEPTION AT THE CONCOURSE HOTEL*

Saturday, November 16, 1996

8:00-8:30 *Continental Breakfast - Educational Sciences - Room 259*

8:30-10:00 Small group discussions

- Sharon Derry - moderator

10:00-11:00 "Talking Across Disciplinary Boundaries in Design-Oriented Work"

- Rogers Hall and Reed Stevens - University of California, Berkeley

Discussion of Hall and Stevens presentation

11:00-11:15 *BREAK*

11:15-12:15 "Developing a Common Voice: Interdisciplinary Teams Engaged in the Process of Design"

- Leona Schauble - UW Madison

"What Leads to a Successful Collaboration Among Cognitive Scientists?"

- Christian Schunn - Carnegie Mellon University

Discussion of Schauble and Schunn presentations

12:15-1:15 *LUNCH on 13th Floor, Ed Sciences Building*

1:15-2:15 "Interdisciplinary Study of Group Performance"

- Keith Sawyer - Washington University

"Interdisciplinary Collaboration: Insights from Music"

- Nick Flor - Carnegie Mellon University

Discussion of Sawyer and Flor presentations

2:15-3:15 Panel on research approaches:
Randy Hirokawa, John Smith, Leona Schauble, others

- Sharon Derry - moderator

3:15-3:30 Closing comments/Discussion

Appendix B: List of Participants

"Understanding Interdisciplinary Teamwork:
Challenges for Research and Practice"
Room 259 - Educational Sciences Building
UW- Madison
November 15-16, 1996

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